
दृढ़ीकृत कंक्रीट — परीक्षण पद्धतियाँ

भाग 5 दृढ़ीकृत कंक्रीट का अविनाशी परीक्षण

खण्ड 3 कार्बनीकरण की गहराई का परीक्षण

(पहला पुनरीक्षण)

Hardened Concrete — Methods of Test

Part 5 Non-Destructive Testing of Concrete

Section 3 Carbonation Depth Test

(First Revision)

ICS 91.100.30

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FOREWORD

This Indian Standard (Part 5/Section 3) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

Testing plays an important role in controlling the quality of cement concrete work. Systematic testing of the raw materials, the fresh concrete and the hardened concrete, is an inseparable part of any quality control programme for concrete. This helps achieve a higher efficiency of the materials used and greater assurance of the performance of concrete, in regard to workability, strength and durability. The test methods used should be simple, direct and convenient to apply. This standard was formulated with this objective in view.

This standard was first published in 1959. In this first revision, it was decided to review and update the various existing test methods of hardened concrete. This revision of the standard is being brought out taking into consideration the latest international practices and developments in this field in the country, and also introduces certain new test methods wherever required. In the process, the various existing test methods covered in IS 516 : 1959 'Methods of tests for strength of concrete' have been revised taking into consideration primarily the corresponding ISO standards while also examining the other best practices worldover and in the country. In addition, test methods for determination of additional properties have been included in areas such as permeability, initial surface absorption, corrosion of reinforcement, carbonation of concrete (field test), accelerated carbonation test, creep of concrete and flexural strength and toughness parameters of fibre reinforced concrete. Also, for better understanding and implementation, some of the other test methods for hardened concrete which were spread over in number of other Indian Standards have been brought together under the fold of IS 516 as its various parts, such as the splitting tensile strength, ultrasonic pulse velocity test, rebound hammer test, bond in reinforced concrete, and determination of water soluble and acid soluble chlorides. This is with a view to making the standard complete in all respects, and rendering it a comprehensive source of provisions for testing of hardened concrete and reference in other Indian Standards.

In this revision, IS 516 is split into 12 parts. The other parts in the series are:

- Part 1 Determination of strength of hardened concrete
- Part 2 Determination of properties of hardened concrete other than strength
- Part 3 Making, curing and determining compressive strength of accelerated cured concrete test specimens
- Part 4 Sampling, preparing and testing of concrete cores
- Part 6 Determination of drying shrinkage and moisture movement of concrete samples
- Part 7 Determination of creep of concrete cylinders in compression
- Part 8 Determination of modulus of elasticity
- Part 9 Determination of wear resistance
- Part 10 Determination of bond in reinforced concrete
- Part 11 Determination of Portland cement of hardened hydraulic cement concrete
- Part 12 Determination of water soluble and acid soluble chlorides in hardened mortar and concrete.

This standard (Part 5) specifies non-destructive test methods for use on hardened concrete in the following sections:

- Sect 1 Ultrasonic pulse velocity
- Sect 2 Half-cell potentials of uncoated reinforced steel in concrete
- Sect 3 Carbonation Depth Test
- Sect 4 Rebound hammer Test

In view of the limitations of each method of non-destructive testing of concrete, it is essential that the results of tests obtained by one method should be complemented by other tests and each method should be adopted very carefully.

(Continued to third cover)

*Indian Standard***HARDENED CONCRETE — METHODS OF TEST****PART 5 NON-DESTRUCTIVE TESTING OF CONCRETE**

Section 3 Carbonation Depth Test

*(First Revision)***1 SCOPE**

This standard IS 516 (Part 5/Sec 3) specifies a non-destructive test method for use on hardened concrete, namely determination of carbonation depth.

2 INTRODUCTION**2.1 Carbonation Process**

Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous cover concrete and may reduce the pH to 8 or 9, at which the passivating/oxide film is no longer stable. Carbonation process involves the following two stages: First, the atmospheric carbon dioxide (CO_2) reacts with water in the concrete pores to form carbonic acid (H_2CO_3). This is followed by reaction of the carbonic acid with calcium hydroxide [$\text{Ca}(\text{OH})_2$] to form calcium carbonate (CaCO_3). This process leads to cause a reduction in the pH value of the pore solution from 12.5 to 13.5 to around 8 to 9, which causes depassivation of protective layer of the reinforcement bars and initiates their corrosion.

2.2 Factors Influencing the Rate of Carbonation of Concrete

- a) Amount of CO_2 in air;
- b) Relative humidity of concrete;
- c) Amount of precipitation of CaCO_3 ; and
- d) Concrete carbonation resistance (concrete permeability and amount of $\text{Ca}(\text{OH})_2$ in concrete).

3 PROCEDURE FOR MEASUREMENT OF CARBONATION DEPTH**3.1 Preparation of Indicator Solution**

The indicator solution shall be 1 percent phenolphthalein solution in ethanol. This is prepared by dissolving 1 g of phenolphthalein powder in a 100 ml solution of 70 ml ethanol and 30 ml of de-ionised water.

3.2 Preparation of Sample

The test shall be performed on freshly exposed concrete surface. This may be either freshly broken surface of concrete or extracted concrete core sample which may preferably be split and the test may be conducted on the split face. If facility for splitting is not available, then the core may be surface dried and sealed to prevent further carbonation. After breaking, the concrete surface shall immediately be cleared of any dust or loose particles.

3.3 Test Procedure

The freshly exposed concrete surface prepared as per 3.2 shall be sprayed with a fine mist of indicator solution. Care shall be taken to avoid the formation of flow channels on the test surface.

The measurements shall be conducted soon after the colour has stabilized. The demarcation between the region, which turns into magenta (dark pink color) and the region showing no change in colour will indicate the carbonation front. The carbonation depth shall be measured on the exposed face.

When the carbonation front runs as a straight line parallel to the surface, the depth of carbonation d_k is determined as shown in Fig. 1A.

When the carbonation front runs as shown in Fig. 1B, a graphical average d_k and the maximum depth $d_{k \text{ max}}$ should be recorded.

Ignore greater depths of carbonation in the corner areas of laboratory specimens, where carbon dioxide has penetrated from two sides at once.

NOTES

1 The measured depth of carbonation may be influenced by the time of measuring after application of the indicator solution. A stable reading may be obtained after about 5 to 10 min after spraying.

2 If only a weak colouration or none at all appears, it is better to repeat the spray after the surface has dried.

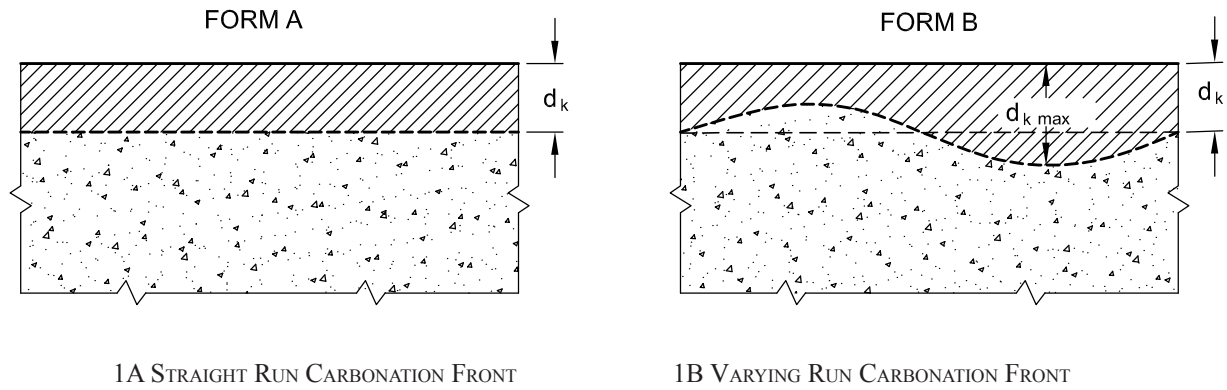


FIG. 1 DEPICTION OF DEPTH OF CARBONATION

4 CORRECTIONS FOR CARBONATION DEPTH MEASUREMENT

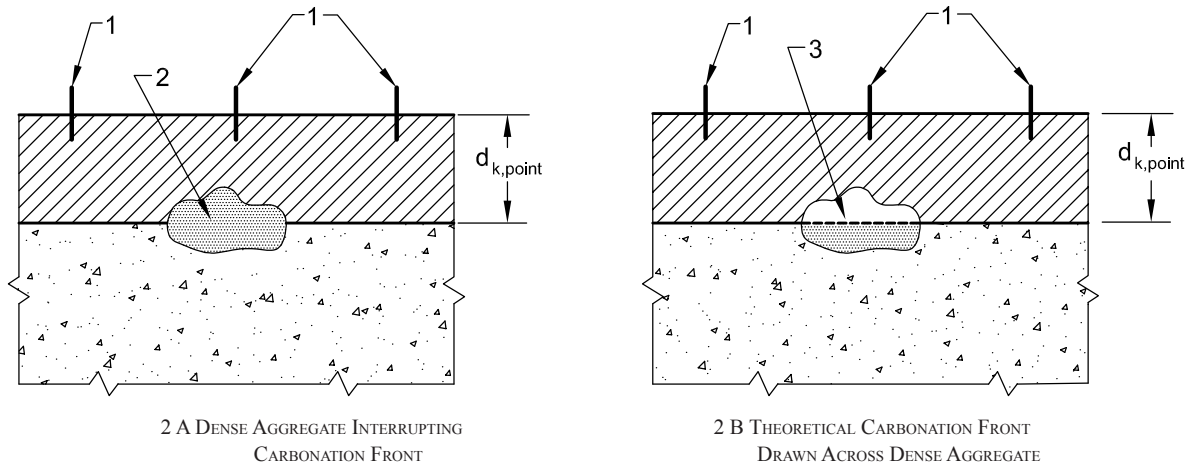
4.1 Procedure for Carbonation Depth Measurement when a Measurement Point Falls within a Dense Aggregate

Dense aggregate particles that lie within the carbonation front will have no effect by the phenolphthalein solution and the carbonation front will be interrupted by the particle (*see* Fig. 2A). For determining the carbonation depth, the theoretical carbonation depth at the plane of intersection of the location point, a line connecting the starting and ending point of the aggregate particle, shall be used (*see* Fig. 2B).

4.2 Procedure for Carbonation Depth Measurement when a Measurement Point Falls on an Air Void

When there are pores present in the area of the carbonation front, extreme values of the carbonation depth may appear (*see* Fig. 3). Where the measured values of Δd_k are less than 4 mm, they shall be used in the calculation of the mean carbonation depth. Higher values of Δd_k shall not be included when calculating the mean carbonation depth.

NOTE – Similar interference may also be observed in the case of porous aggregates.

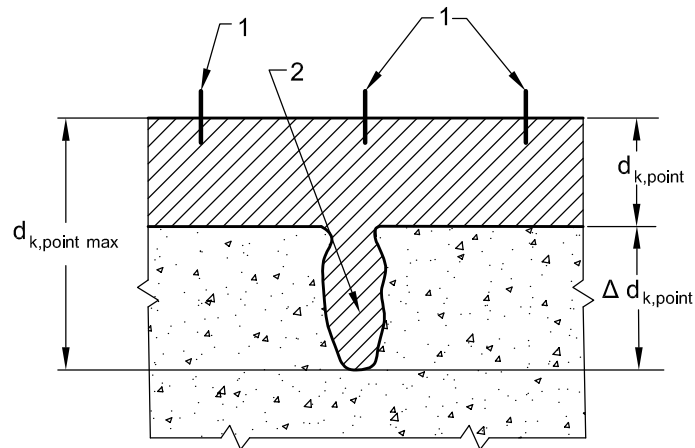


Key

- 1 Measuring points
- 2 Dense aggregate
- 3 Theoretical carbonation front

$d_{k, \text{point}}$ = measured depth of carbonation

FIG. 2 DEPICTION OF CARBONATION DEPTH WHERE THE POINT FALLS WITHIN A DENSE AGGREGATE PARTICLE



Key

- 1 Measuring Points
- 2 Air Void

where

- $d_{k,point}$ = measured depth of carbonation;
- $d_{k,point max}$ = measured depth of carbonation including the air void;
- $\Delta d_{k,point}$ = depth of air void.

FIG. 3 DEPICTION OF CARBONATION DEPTH WHERE THE POINT FALLS ON AN AIR VOID

5 TEST RESULTS

The depth of carbonation for exposed face of a specimen ($d_{k,face}$) shall be calculated and recorded. A minimum of three specimens shall be taken from each structural member. The mean depth of carbonation for each structural member ($d_{k,spec}$) shall be calculated and recorded.

5.1 Test Report

The test report shall contain the following:

- a) Details of the concrete mixes/grade of concrete, if known;
- b) Reference of the concrete under test such as location of member or any other identification code;
- c) Age of structural member;
- d) Date of test;
- e) Mean carbonation depth of concrete in structural member;
- f) Individual test results and average results with relevant photographic records including details on non-linear carbonation front and corrections due to dense aggregates/air voids; and
- g) Any additional comments or observations.

ANNEX A

(Foreword)

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(Continued from second cover)

This standard (Part 5/Sec 3) covers the procedure for measurement of carbonation depth of a structural member. This is a new test method included in the IS 516 series. The test is carried out by spraying phenolphthalein solution on a freshly exposed concrete surface. The standard gives,

- a) preparation of phenolphthalein solution;
- b) procedure for exposing the concrete test surface;
- c) detailed procedures for measurement in case of linear and non-linear carbonation front; and
- d) corrections to measurement in the presence of aggregate or air void on the test surface.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

In the formulation of this standard, assistance has been also derived from RILEM CPC-18 'Measurement of hardened concrete carbonation depth'.

In reporting the result of a test or analysis made in accordance with this standard, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that specified value in this standard.

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This Indian Standard has been developed from Doc No.: CED 02 (13831).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi